SECTION 16126

DC POWER CABLE AND DC POWER FEEDER DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Included: This Section specifies the following:

1. Furnishing, installing, testing, terminating and splicing EPR and XLPO insulated DC power cables and 1000 Amp feeder disconnect switches.

2. Furnishing, installing, terminating, splicing, and testing new 1,000,000 circular mils ethylene propylene rubber (EPR) insulated cross-linked polyolefin (XLPO) jacketed cable for 650VDC positive feeders.

3. Furnishing, installing, terminating, splicing, and testing, new 1,000,000 circular mil cross-linked polyolefin (XLPO) insulated cable for 650 VDC negative feeders.

4. Furnishing, installing, connecting and testing of manual DC traction power disconnect switches as shown on Contract Drawings.

5. Furnishing and installing of galvanized steel channel supports, miscellaneous cable clamps, exterior grade FRE conduit, cable terminations, and cable insulators for DC cables as shown on the Contract Drawings.

6. Furnishing and installing (trolley) taps of 4/0 AWG extra flexible cable as described hereafter.

7. Furnishing and installing 4/0 AWG rubber insulated, neoprene jacket cable as described hereafter.

8. Installation of new cable tags.

1.2 REFERENCES

A. Pertinent latest edition provisions of the following listed standards shall apply to all work of this Section, except as modified herein, and are hereby made part of these specifications to the extent required.

1. American Society for Testing and Materials (ASTM)

   a. B8 - Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft

b. B33 - Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes

c. B172 - Standard Specification for Rope-Lay-Stranded Copper having Bunch-Stranded members for electrical conductors.

1.3 SUBMITTALS

A. Submit the following for each type of cable in accordance with Section 01300.

1. Shop drawings, catalog cuts, and descriptive data.

2. Special storage instructions

3. Installation, termination, splicing and repair materials and procedures recommended by the cable manufacturer

4. Certificates of Compliance in accordance with the Supplementary Conditions.

B. Submit the following for dc traction power disconnect switches in accordance with Section 01300.

1. Detail drawings of the disconnect switch and enclosure, including composite of switch in enclosure

2. Bill of material

3. Data sheets noting the electrical and thermal ratings of the switch

4. Switch assembly drawings, outline and detail drawings of switch enclosure, showing materials, methods of assembly, anchorage to other work and other significant data for cable racks, cable clamps and cable splicing components.

5. Certificates of compliance to these Specifications and testing criteria

6. Design test reports as specified in MBTA Specification P-150C.

C. Submit factory test reports in accordance with Sections 01300 and 01400.

D. Prior to making splices, submit the name and qualifications of each individual who will perform cable splicing including experience on similar previous projects.

E. Submit materials list and assembly details of cable support arrangements, porcelain cable clamps and aerial termination details.

1.4 DELIVERY AND STORAGE

Ship cable on reels suitably covered to protect the cable from damage during shipment. Seal, secure, and protect cable ends from damage. Make both ends available for testing, unless prevented by cable size or reel construction. The cables shall be stored in accordance with the manufacturer's instructions to protect them from damage.

1.5 QUALITY CONTROL

A. Conduct factory and field testing in accordance with Section 01400.

B. Cable splicers: certified by the Engineer and experienced in making or breaking splices of similar cables for similar application (minimum five years proven experience).

C. The Authority may request the splicer to make test splices in the presence of the Engineer before certification is granted.

PART 2 - PRODUCTS

2.1 GENERAL

All insulators, connectors and support hardware for installation of new traction power feeder and negative return cable shall be new, having the physical dimensions, electrical ratings and mechanical strength required for the intended service as shown on the Contract Drawings and as specified herein.

2.2 DC TRACTION FEEDER POSITIVE CABLE & NEGATIVE CABLE

A. Cables covered in this Article are intended for use in DC traction service operated at nominal 625 volts subjected to additional voltage stresses resulting from the operations of trolley buses and rectifier equipment. Cables shall be suitable for installation in dry or wet locations, in exposed or underground conduits, trays, cable racks, directly buried or run exposed.

B. Furnish 1,000,000 circular mils, single conductor, EPR insulated, XLPO jacketed cable in accordance with MBTA Specification P-118C, included as Appendix to this Section.

C. Furnish 1,000,000 circular mils, single conductor, XLPO insulated cable in accordance with MBTA Specification P-119C, included as Appendix to this Section.

D. Furnish 4/0 AWG, single conductor, rubber insulated, neoprene jacket in accordance with MBTA Specification P-30C, included as Appendix to this section.

2.3 MISCELANEOUS INSULATED CABLE

A. No. 4/0 AWG Extra-Flexible Cable

1. Cable shall be black, extra flexible, ethylene-propylene rubber insulated, neoprene or hypalon jacketed in accordance with applicable requirements of ICEA No. S-68-516/NEMA No. WC8-1976. The cable shall contain 550 strands of No. 24 wire with rope-lay-stranding, 5/64 inch insulation and 3/64 inch jacket and shall be rated 1,000 volts, 90˚C. The cable shall be marked at intervals no more than 36 inches to show manufacturer's name and year of manufacture. AWG size, voltage class, type and thickness of insulation (mils), and type and thickness of jacket (mils).

B. The tie wire used with pin-type insulators shall be No. 8 AWG copper, 19 strand, with black XLP insulation.

2.4 TRACTION POWER DISCONNECT SWITCHES

A. Furnish open knife type, unfused, no load break, single throw, front-connected, front operated disconnect switches mounted on insulated base for disconnecting the feeder cables from substation to the distribution cables or from distribution cables to overhead trolley taps as shown on the Contract Drawings.

B. Furnish new traction power 1,000 A disconnect switches and enclosures in accordance with MBTA Specifications P-150C, included as Appendix to this Section.

2.5 AERIAL CABLE SUPPORT

A. Strain insulators shall contain 5/8-inch diameter epoxy-fiberglass fittings with clevis end and eye end at right angles. Nominal length inches and maximum design tension shall be 10,000 pounds.

B. Strain clamps for traction feeder cable shall contain two mating pieces connected with U-bolts. One end shall contain an offset clevis fitting for attaching to eye of insulator, the other end a pulling eye. Slip strength shall be 7,000 pounds minimum.

C. Ferrous hardware, including bolts, nuts, and washers shall be hot-dip galvanized as indicated on the Contract Drawings.

2.6 CABLE CONNECTORS, CLAMPS, CONDUIT AND HARDWARE

A. Connectors for connections to new supplementary cables shall be mechanical, parallel groove type of high strength, high conductivity copper alloy. Run and tap grooves shall be sized as noted on Contract Drawings. All connectors shall be new.

B. Connectors for splicing supplementary cable shall be full tension compression type as recommended by the cable manufacturer.

C. Beam clamps, cable supports and dead-ending hardware shall be furnished in accordance with details on Contract Drawings.

D. Cable clamps of two-piece paraffin-impregnated maple wood blocks for supporting riser cables or tap cables on beams, channel, or span wires shall be furnished either separately or as part of an assembly as shown on the Contract Drawings.

E. All feeder cables, positive and negative, with the exception of the aerial cables running from the second level of the garage to the Maintenance Building, shall be installed in FRE conduit. FRE conduit shall be suitable for outdoor exposure and shall be in accordance with MBTA Specifications P-175, included as Appendix D of the Section. FRE conduit shall be located and installed in accordance with the details on the Contract Drawings.

2.7 FACTORY TESTS

A. Conduct tests in accordance with Section 01400 and the following.

1. Cable: standard manufacturers' tests and in accordance with the following standards: NEMA WC8; ANSI/IEEE-48; ANSI/IEEE-400; ANSI/IEEE-532; and ANSI/UL-1072.

2. Disconnect Switches:

   a. Allowable maximum temperature rise of the switch parts during continuous operation at rated current as specified in ANSI C37-3 when the ambient temperature outside switch in its enclosure is 40˚C.

   b. Allowable maximum temperature rise when operating at overload capacity as specified for 15 seconds every 90 seconds over a two-hour period.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. The Contractor shall inform the Engineer about any field conditions encountered which are not covered or are substantially different from those shown on Contract Drawings or specified in this Specification and perform the work in question in accordance with the Engineer's instructions.

2. The Contractor shall coordinate this work with the installation of the overhead contact system. All riser and tap connections in the overhead system work area shall be completed prior to turning over the overhead system to revenue service.

3. The Contractor shall conform to safety features and requirements specified, especially the requirements related to safety vests and

flagmen.

B. Insulators and Hardware

1. Insulators and hardware shall be assembled and installed as shown on Contract Drawings. Nuts shall be tightened with locknuts and cotter pins properly installed. Nuts and cotter pins shall be oriented toward the pole or downward as applicable.

2. Hardware shall be inspected for missing parts and visual defects prior to installation. All metal shall be free of dirt, corrosion or damage to the galvanizing.

3. Insulators shall be bright and clean when installed. Abrasive materials shall not be used for cleaning of insulators. Chipped or cracked insulators shall not be reused.

C. Feeder Cable Stringing

1. Cables shall be handled with care. Cables shall not be run over by vehicles or any other object that could damage the insulation or conductors. Each reel shall be examined for cuts, kinks, or other damage. Damaged portions shall be removed and replaced or repaired as directed by the Authority.

2. Temporary guard structures shall be installed as required to maintain adequate clearance over roads and other lines.

3. Scrap materials such as timbers or other supports, shall be gathered up and disposed of in a manner satisfactory to the Authority. The scrap cable pieces shall be salvaged and returned to the Authority.

4. The cable shall be inspected continuously as it leaves the reel. If severe cuts are detected, the stringing operation shall be stopped until the damage is repaired. Repair sleeves may be used only with permission of the Authority. Damaged cable shall not be installed without repair.

5. No splices shall be permitted in spans over road crossings. In other spans, only one splice per span will be permitted in each wire and this splice shall not be within 10 feet of any structure. Splices shall not be pulled through stringing sheaves or sagging blocks.

6. Stringing tension shall be adjusted to correspond to the conductor temperature as shown on Contract Drawings. The conductor temperature shall be measured after taping a bulb type thermometer in contact with the bare conductor and shading the thermometer from direct sunlight. The Contractor shall record conductor temperature and tension at each end of the cable length and any temperature variations during sagging operation. These records shall be retained and copies submitted daily to the Engineer. All supplementary cables in the same span, whether existing or new, shall be sagged evenly. The erection

tension shall be within plus or minus one percent of the value shown on the Contract Drawings. The Contractor shall correct any cable length installed at incorrect tension.

7. All equipment such as sheaves, clamps, come-alongs, and tension stringing equipment shall be in good condition. Any such equipment that, in the opinion of the Authority could result in damage to the cables shall be removed from the work site.

8. Stringing blocks shall be properly mounted on the pole or crossarm in such a manner that no binding shall occur while stringing. Stringing blocks that are not properly maintained shall not be used and shall be removed from the job site.

D. Aerial Cable Splicing and Terminating

1. The Contractor shall splice the aerial cables only where permitted in Article 3.1 of this Section.

2. In order to obtain optimum electrical contact and adequate insulation at the points of connection of each cable, only the most highly skilled cable splicers shall be employed. Cable splicers shall have experience in making splices of similar cables for similar applications. The Contractor shall submit the name of the individual, with the number of years and type of experience on similar projects. The Contractor shall obtain prior approval of all individuals who will be making splices.

3. Each splicer shall be approved for the job by the Authority prior to any splicing activities. The Authority may request the splicer to make test splices in the presence of the Engineer before the approval is granted.

4. All faulty, imperfect, or damaged splices found during or after installation, shall be removed and replaced. New splices shall be subject to the same tests as are required for the cables after initial installation.

5. The Contractor shall splice the aerial cables using a full tension compression type connector recommended by the cable manufacturer for the conductor size and expected service conditions and shall cover the joint and seal the cable insulation using heat shrinkable insulating tubing.

6. Full tension cable splices shall be installed with the cable laid out in a straight line for approximately 10 feet on each side of the connection.

7. Ends of the aerial cable shall be sealed or terminated at pole mounted disconnect switches as shown on the Contract Drawings.

E. Other Cables

1. The Contractor shall install other overhead cables and cable assemblies as shown on the Contract Drawings, such as feeder taps and equalizer

jumpers.

2. Riser cables shall be supported using new split maple clamps as shown on the Contract Drawings. Tap cables shall be supported on support brackets or span wires using new clamps as shown on the Contract Drawings.

3. The Contractor shall cut new riser and tap cables to final length, install lugs and clamps, and connect these cables to disconnect switches and trolley wires, respectively.

4. The Contractor shall reinsulate the cable at locations where tap connections are removed from new supplementary cable and thermo-seal the exposed ends of all new cables after cutting if final connection will be delayed.

5. Current-carrying connectors shall be installed in accordance with the following:

   a. Wire surfaces, which are in contact with conducting surfaces of the connector, shall be thoroughly wire brushed and shall have an inhibitor applied. Where connectors are not factory-loaded, the same inhibitor shall be applied in the field to the connector.

   b. Corrosion inhibitors shall be stable over a wide temperature range, able to adhere to cold metal surfaces, water-repellent, weather resistant, and inert to copper, aluminum, zinc, tin, cadmium, steel, and neoprene rubber. Grit-bearing inhibitors shall be used except for flat lugs, sliding surfaces or where omission is recommended by the connector manufacturer. Grit shall be compatible with the connector and wire metal. Inhibitor for copper and bronze shall be T&B "Kopr Shield", Fargo "Fargolene", Penn-Union "Cual-Aid", Burndy "Penetrox A", or approved equivalent.

   c. Bolts in bolt-type connectors shall be lubricated as recommended by the manufacturer and torqued to the manufacturer's recommendation using a calibrated torque wrench.

6. The 4/0 AWG cable is used to provide 600-volt power to the three stinger control panels as shown on the Contract Drawings. Install and connect to the manual disconnect switch in the shop three 4/0 cables, install each of the cables in FRE conduit and terminate the cables at the three stinger control panels. In additional, install and spice three 4/0 cables from the negative return cable to the three stinger control panels. The negative cables should also be installed in FRE conduit.

F. Control of Scrap

Scrap components including retired ac and dc cable shall be collected, removed daily from the job site and disposed of by the Contractor.

G. Installation of Traction Power Disconnect Switches and Supports

1. Install traction power disconnect switches assembled in boxes including cable clamp supports, as shown on the Contract Drawings. Install a cable tag on the switch handle as shown on the Contract Drawings.

2. Install switch enclosures plumb and level and in alignment with adjoining work or structure in accordance with the Contract Drawings.

3.2 TESTS

A. General

1. The Contractor shall provide all instruments, materials, and labor required for tests specified herein on the dc traction feeder cable furnished and installed by him.

2. The Contractor shall formulate an overall test program for the installation, which shall include, but not be limited to, the tests specified in this Section to ensure equipment and material compliance with the relevant standards, this Specification and satisfactory and reliable performance in actual intended operation.

B. Conditions for Tests

1. Prior to testing of any cable and the installation, the following conditions shall be fulfilled by the Contractor:

   a. The Contractor shall have in his possession, all the Shop Drawings duly approved by the Engineer.

   b. The Contractor shall have submitted testing procedures for the Engineer's approval at least 45 days in advance of the testing.

C. Witnessing Tests

The Engineer will witness complete field- testing on all the cable installation.

D. Responsibility

The Contractor shall assume full responsibility during field-testing of all cable installation provided by him. Should there be any loss or damage to such cable or installation as a result of these tests, the Contractor shall be fully responsible for replacing the damaged cable. Replacement of damaged cable shall include all costs, including, but not limited to, removal of damaged cable, furnishing of, transportation of, and installation of replacement cable.

E. Rejection and Retesting

1. Failure of cable or splice to withstand tests or to meet ratings shall be sufficient grounds for rejection of the item tested.

2. Any cable or splice rejected shall be retested in the presence of the Engineer after rectification.

3. If it is not possible to rectify rejected cable to the satisfaction of the Engineer, new cable shall be installed.

F. Costs of Tests

The price for conducting all field tests and checkouts in the presence of the Engineer, including entire cost of rectification, retesting, and/or supplying of new items shall be deemed to be included in the Contract Price.

G. Field Tests

1. All Contractor-installed dc positive traction feeder cables shall be tested to ascertain that the dielectric strength of the cable insulation has not been impaired during installation, that the splices and terminations are properly made and to confirm the integrity of the cable system prior to energization. Tests shall include continuity tests, insulation resistance tests and high potential direct current tests. High potential direct current tests specified herein shall be applicable only to dc positive cables. Rectification of defects of any cable shall be done only with the specific approval of the Authority.

2. Acceptance Tests: After installation of any length of a cable and completing all connections to risers, jumpers, and taps, the Contractor shall perform the below listed tests on each cable circuit. To preclude damage to equipment and devices the tests shall be conducted before the cable is connected to the disconnect switches and trolley wires.

    a. Continuity Test: This test shall be performed to prove the continuity of cable circuits.

    b. Insulation Resistance Test

        1) This test shall be performed to determine the cable insulation resistance to ground.

        2) Tests shall be conducted with a 1,000-volt motor operated megger. Test voltage shall be applied between the conductor and ground and shall be held until the reading reaches a constant value for five minutes. Insulation resistance values obtained by the megger tests shall not be less than two megohms. The Contractor shall bring to the attention of the Engineer, the results of similar tests having unequal ratings with the variations of 25% or more.

        3) For each test, the Contractor shall record the temperature, humidity, duration of the test and the voltage of the megger used.

c. High Potential Test, dc positive cables: This test shall be performed only after the insulation resistance test has been successfully completed and shall be performed on each cable circuit installed under this Contract. Before conducting the high potential direct current tests, the Contractor shall comply with the following requirements:

1) Nearby equipment, the conductors of nearby insulated cables not under test, except those in service, and the ground stick shall be all securely tied to the grounding system.

2) The insulated conductor under test shall have a safe clearance from adjacent conductors and surrounding metal objects. For every 1,000 volts of dc test voltage, 1/4-inch clearance is regarded as a safe distance.

3) High voltage tested gloves shall be worn by each participant.

4) The test voltages shall meet the recommendations of the cable manufacturer.

5) Danger signs and sentries shall be posted at all critical points along the entire cable route under test.

6) The operator's manual for the particular test set being used shall be read and understood.

7) All safety precautions shall be observed at the testing end and at the far end of the cable.

d. Each cable circuit shall be tested separately while grounding test equipment and all cables not under test, except those in service. The following test procedure shall be followed:

1) The test equipment shall be supplied from a stable, constant voltage source having a maximum variation of the voltage of plus or minus five percent. Preferably, a motor-driven generator shall be used for the supply. The output voltage of the test set must be filtered, regulated, and spike free.

2) The direct current test voltage shall be applied between conductor and ground slowly in equal steps (in steps of five to seven percent of full test voltage) until the designated test voltage is reached. The rate of voltage acceleration shall be consistent under each step.

3) Sufficient time shall be allowed after each step for the leakage current to stabilize.

4) Total leakage current shall be recorded in micro-amperes after

each step. The same length of time shall be allowed after each step for the total current to stabilize before taking the readings.

5) The test voltage shall be 80% of the original factory test voltage. The test voltage shall be maintained for five minutes after it has reached the specified value.

6) Total current values shall be recorded in micro-amperes at one minute intervals for the duration of the test.

7) The test set voltage control shall be set at zero at the end of each test. The residual voltage on the circuit shall be allowed to decay to approximately 1.0 kV before applying the manual grounds.

8) The insulated conductor under test shall be grounded with ground stick after each test. The conductor should remain grounded for at least 30 minutes after completion of the test.

e. Failure of the initial leakage current to decrease, or any increase in the leakage current at any time during the test shall be presumed to be indicative of a cable defect and the test shall be continued until cable failure occurs.

H. Defective Cables

1. Any Contractor furnished cable found defective before installation shall be replaced by the Contractor. Cable found defective after installation shall be repaired or replaced at Contractor's expense.

2. Any cable section installed under this Contract found defective during the testing shall be replaced with a new cable section. Rectification of defects of any cable shall be done only with the specific approval of the Authority.

I. Test Reports

The Contractor shall submit five copies of certified test reports of all field tests for the Engineer's review and approval. Test reports of field tests shall be submitted no later than seven days after testing. Test reports shall be self-explanatory, noting the personnel involved, and shall show the instruments used for testing and the date(s) of their last calibration. Test reports shall contain identification of each conductor tested in a manner that can be referenced to the Contract Drawings.

3.3 CABLE IDENTIFICATION TAGS

Install standard cable tags on new cables, two cable tags to each box, one cable tag on the cable in the box and one cable tag on the cable below (or above) the box. The aerial cable tag will be the standard MBTA embossed

aluminum tag.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

No separate measurement and payment will be made for work under this Section. All costs in connection therewith will be considered incidental to the work for which it pertains. Traction power disconnect switches and dc distribution cabling, lightning arresters, cable support and terminations, including materials, labor and equipment, will be paid for under (pay item 1630.211) DC Electrification in Section 16123 – OVERHEAD CONTACT SYSTEM INSTALLATION.

END OF SECTION